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Continued experiments on the excitation of spectra by high frequency pulses

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With 1 plate and 1 figure in the text

Introduction

In previous papers arrangements to excite spectra by high-frequency pulses have been described [1, 2]. The experiments have been continued, and in order to increase the high-frequency power it was decided to construct a new power amplifier containing two 25 kW triodes of the same kind as the single one used in the recently described installation [2]. We have tried to obtain a coupling that is as insensitive as possible to the particular loading represented by the plasma in the discharge tube with its varying degree of ionization.

The transfer of large high-frequency pulse powers from the generator to the gas in the discharge tube is a problem which has also been investigated.

Power amplifier and discharge tube tuning circuit

The new power amplifier (Fig. 1) consists of two water-cooled triodes *TBW* 12/25 normally intended for an anode voltage of 12 kilovolts and having a maximum permissible plate dissipation of 25 kilowatts each. The filaments are separately fed from transformers controlled by variacs. The input circuit of the power amplifier is arranged as a conventional push-pull circuit by means of a center-tapped coil and a split-stator capacitor. Driving power is taken from the original driving unit [1], which is link-coupled to the grid circuit through a faraday screen; this was found useful in isolating the power amplifier from the driver. To prevent parasitic oscillations it was necessary to insert damping resistors in the grid connections of the amplifier tubes. The bias for class C operation is obtained from a separate supply. The bias voltage is controlled by means of an instrument in the grid circuit; another meter in the same circuit is used to control the tuning and the grid excitation. Preliminary tests were made with a balanced output circuit in the power amplifier, i.e. push-pull working. Difficulties arose, however, in maintaining a complete neutralization because of the varying loading conditions, which are connected with the varying degree of excitation of the filling-gas in the discharge tube. This could cause the build-up of uncontrollable selfoscillations in the power amplifier. The push-pull arrangement was consequently abandoned and a single-ended anode

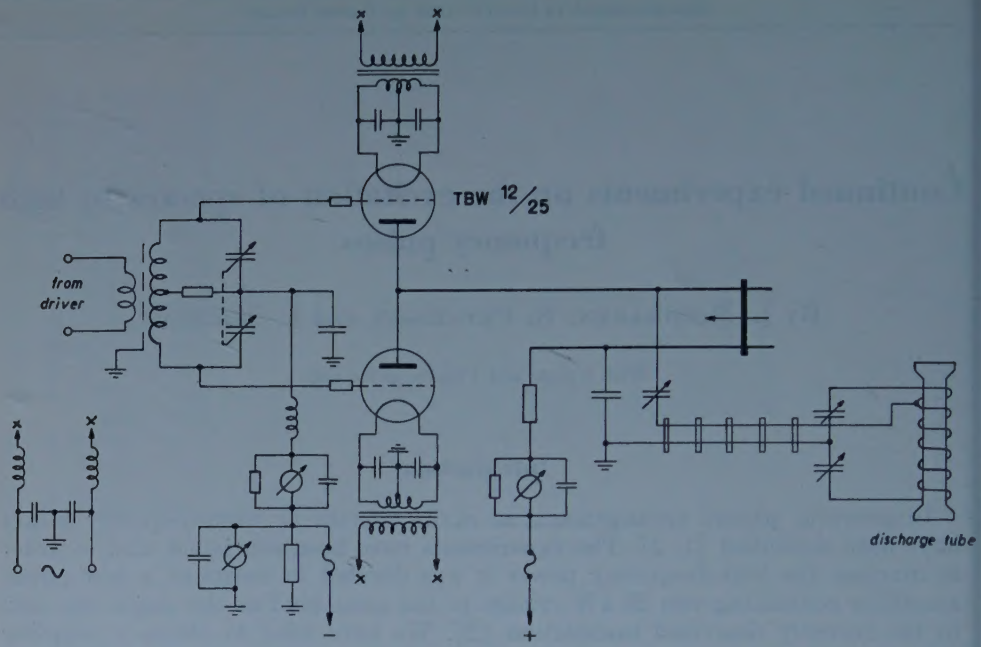

Fig. 1. Schematic diagram of the power amplifier and the discharge tube tuning circuit.

circuit was tried with much greater success. This so-called push-push coupling, which has a reasonably good anode efficiency in spite of its characteristically doubled output frequency, requires no neutralization. The inductance of the anode circuit is effected by means of two parallel brass tubes, about 2 cm in diameter, with a 12 cm spacing. This line is tuned by means of a movable shorting bar.

The transfer of large high-frequency powers from the amplifier to the discharge tube tuning circuit depends largely on the coupling between them, and much work has been expended in experiments in order to obtain optimal conditions. The coupling is shown in Fig. 1. The input end of the open wire feeder is connected to ground and to a point on the anode tuning line of the power amplifier, and the output end to two points on the final tuning circuit, one on the coil surrounding the discharge tube and one on the line between the two tuning condensers. It was also found that this arrangement reduces the tendency for flash-overs between the coil and the walls of the discharge tube.

As indicated above the push-push coupling implies a doubling of the output frequency for a given input frequency. Since the driver frequency was maintained at 9 megacycles per sec the present output frequency is 18 Mc per sec. During pulse operation the anode voltage of the power amplifier tubes can be raised to about 20 kilovolts; the pulse duration and the repetition frequency are adjustable within wide limits, as previously described [1, 2]; the values of these three parameters are chosen so as to get a mean power in the discharge tube which is suitable in relation to the cooling conditions. A typical set of values, corresponding to maximal pulse power, is 20 kV, 80 microsecs, and 40 pulses per sec, respectively. The pulse power transferred to the discharge tube was not measured directly but estimated from the mean power and the pulse data.

The doubling of the frequency has caused no marked change in the transferred energy.

Experiments with xenon as a filling-gas

The discharge tube—made of fused quartz—was attached by means of a large ground socket to the cone-shaped slit tube of a 1.5-meter concave-grating, grazing-incidence, vacuum spectrograph, covering the 2000–500 Å range.

The new high-frequency set was tested with xenon as a filling-gas. As in our previous experiments the peak power was raised in steps by increasing the anode voltage of the power amplifier tubes; the influence of the anode voltage on the excitation was observed on a corresponding series of spectrograms. The pulse duration and the pulse frequency were chosen so as to get appropriate mean powers. Plate I shows a series of three spectrograms in the 1260–1100 Å and 930–800 Å ranges taken with 6, 11, and 19 kV anode voltages; the pulse lengths were between 850 and 100 microsecs and the frequency between 120 and 40 pulses per sec.

The Xe I spectrum, which is rather strong for the lowest pulse power, has almost vanished on the second spectrogram; Xe II grows weaker at the highest pulse power; Xe III gains intensity in relation to Xe II, when the peak power is increased; and Xe IV is not present on the low peak-power spectrogram but turns up on the middle one and is enhanced when the peak power is raised to its highest value, and much more so than the Xe III lines, as appears from the λ 1156–1158 group. In the range covered by the spectrograph some preliminary spectroscopic observations have been made. On our low peak-power spectrograms Xe I has been recognized, not only the four lines observed by Boyce [3] but also e.g. $\lambda\lambda$ 1170.4, 1110.7, 1099.7, and 1085.4, which are transitions to the ground term from $2s_4$, $4d_2$, $3s_4$, and $5d_5$, respectively. Concerning the spectra of ionized xenon, Boyce has given 20 identified Xe II lines; on the present spectrograms there are about 75 additional lines, calculable from known energy levels, as well as some unidentified Xe II lines. Boyce lists about 130 identified Xe III lines. In addition, we have more than 100 lines experimentally recognized as belonging to Xe III and calculable from the known levels, and also a number of Xe III lines not yet identified. As to Xe IV no wavelengths are to be found in the literature, the energy levels in the *Atomic Energy Levels* [4] being based on unpublished measurements by Boyce. Our preliminary list contains about 200 Xe IV lines.

Lines of silicon (from the quartz discharge tube), oxygen, nitrogen, and carbon appear as impurities on the spectrograms. The dependence of their intensities on the peak power differs from that of the xenon lines; this is to be seen especially in the case of Si III λ 1206 and C III λ 1174, which are strong on the middle excitation spectrogram only.

The spectrograms are being studied and further results will be published in forthcoming papers.

SUMMARY

A new power amplifier for the excitation of ionic spectra, containing two 25 kW water-cooled triodes, has been constructed. During pulse working the anode voltage of the tubes was raised to 20 kV, the normal value being 12 kV. Arrangements to transfer high-frequency power to the discharge tube have been studied. The set has been tested on xenon in the vacuum ultraviolet and many new Xe II, Xe III, and Xe IV lines have been observed.

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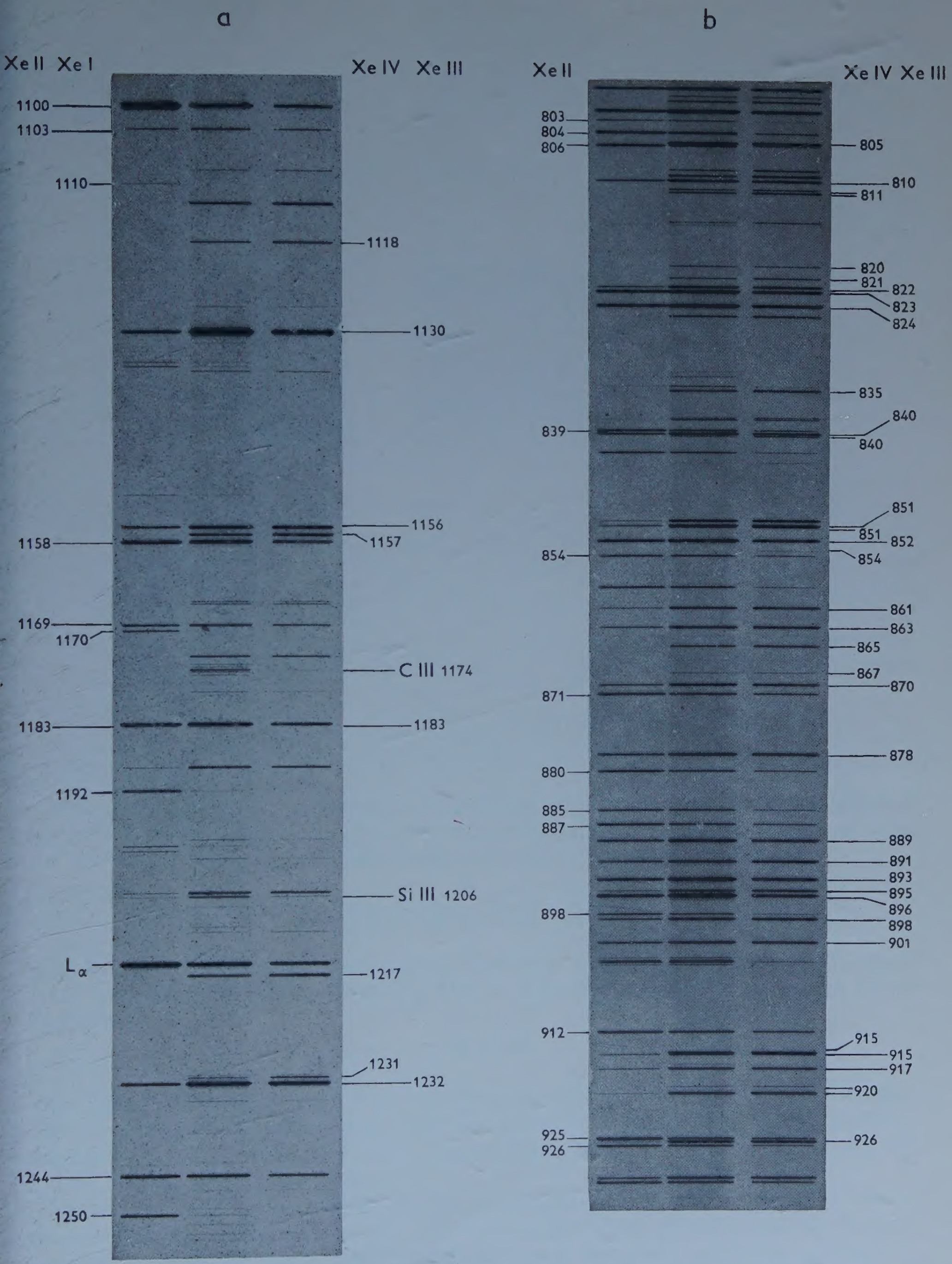

Xenon spectra in the vacuum ultraviolet. The left spectrogram in each of the a and b series corresponds to the lowest high-frequency peak-power and the right spectrogram to the highest peak-power. Some lines of Xe I, Xe II, Xe III, and Xe IV and a few impurity lines are marked.